

## 1. Introduction

**1.1 Proposal definition:** This proposal submits the inactive Homestake mine in Lead, South Dakota as a candidate site for the Deep Underground Science and Engineering Laboratory (DUSEL) in response to the National Science Foundation's solicitation No. NSF-05-506. The Homestake mine is an ideal site for a safe, advanced, dedicated, versatile DUSEL. Full documentation describing the site and the State of South Dakota's actions are at the website: [http://neutrino.lbl.gov/Homestake/S2\\_Supporting\\_Documents/](http://neutrino.lbl.gov/Homestake/S2_Supporting_Documents/).

The most important characteristics of Homestake are:

- A vast site capable of hosting a comprehensive suite of experiments in all major fields of science: low background experiments and very large detectors in particle and nuclear physics; multidisciplinary deep sub-surface studies in geosciences, geoengineering, and microbiology.
- Expandable over 30 years to accommodate an evolving scientific and outreach mission.
- A diverse and scientifically interesting geology.
- A reviewed Conversion Plan for safety, rehabilitation, dewatering and providing safe access to 8000 feet below ground, with anticipated costs of ~\$50M and a duration of ~ 18 months.
- An early implementation option of the Conversion Plan financed by funds available to the State of South Dakota, including five years of operating support, providing access for science from the surface to the 4850 (feet deep) level by Dec. 2006.
- Strong existing efforts to immediately foster Education and Outreach programs at the historic site.
- Strong state and local support for DUSEL, providing technical and logistical support.
- An agreement already consummated for obtaining title to the facility.
- Applications for water discharge permits initiated.
- A century of operations, safety records and maintenance logs, and geologic information.

The reuse of an inactive well-known mine offers many advantages for the formation of a deep underground laboratory. These include:

- Reduced risks, accurate schedules, and lower capital costs.
- Expedient, safe, deep underground access and space provided by existing shafts and drifts with no competing uses.
- Surface facilities situated at the site to support and foster the scientific and outreach programs.
- Identified and accessible rock disposal sites.
- Characterized rock mass, existing drill core repository and mining/geologic database to assist in planning.
- Characterized water inflows and sources.

**1.2 List of sciences served:** In this proposal we show that after regaining access, restoration of excavated space, and new construction, Homestake will be fully capable of addressing many of the most important scientific questions of our time. The importance of these goals has been articulated in a number of nationally prominent reports.<sup>1</sup> In particular, in this proposal we will discuss how Homestake will be developed over a number of years for the following six primary scientific goals. There are experiments that require ultra-low backgrounds and consequently require great depth:

- Detection of neutrinoless double beta decay requiring very low backgrounds from natural radioactivity and cosmic rays.
- Detection of relic dark matter and low-energy solar neutrinos requiring very low backgrounds.
- Measurements of nuclear reaction rates, performed with low energy accelerators, important for understanding the origin of the elements and dynamics of stars.

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<sup>1</sup> 2001 Bahcall report, the National Academy of Sciences Reports *Quarks to the Cosmos*, The 2002 Nuclear Physics Long Range Plan, The NeSS workshop, "Neutrinos and Beyond," The Neutrino Facilities Report, The Quantum Universe: The Revolution in the 21<sup>st</sup> Century Particle Physics, The Earthlab report, DUSEL Science book and the S-1 matrix, and the 2004 Neutrino Matrix APS report, National Science and Technology Council Committee on Science, February 2004, "The Physics of the Universe", "Facilities for Future of Science" DOE office of Science DOE/SC-0078, December 2003.

- Very large multipurpose physics detectors requiring caverns that can accommodate multi-100 kt target mass to detect proton decay, astrophysical and accelerator neutrinos over great distances.

And there are experiments that require diverse geology and long-term dedicated access to large sections of the earth's crust:

- A large network of caverns, drifts, ramps, and boreholes instrumented to gain detailed knowledge of the dynamics of the earth's crust over long periods of time at different distance scales from  $\mu\text{m}$  to km.
- A dedicated laboratory with access to the extreme deep to understand the biology, and biochemistry of the deep environment and to gain knowledge of the limits of life.

We set forth these overarching goals in the fields of nuclear and particle physics, geophysics, geoengineering, and biology as the most important considerations for the development of this facility. Nevertheless, we expect that such a facility could become host to many additional interesting experiments, many of them at the intersections of traditional fields that require an underground environment spanning from the surface to the great depths.

We expect that this laboratory, host to a rich spectrum of science, will be a regional center for outreach and education. Homestake's historic and scenic location provides additional attractions for these efforts. The creation of a comprehensive campus for underground research will enable a diverse program for expanding teaching opportunities, involving students in many fields and coupling to the existing efforts centered in South Dakota and neighboring EPSCoR States, including Native American tribal colleges and K-12 educators programs.

**1.3 Plan of the document:** After a general summary about Homestake in Sec. 2, we discuss in Sec. 3 qualifications of the proponents. In Sec.4 we present the plan for conversion of Homestake mine to DUSEL, while in Sec.5 we discuss an early implementation of the Conversion Plan. In Sec. 6 we present the plan for an initial suite of experiments and in Sec.7 the 30-year capability of the site. In Sec. 8 the plan for scientific stewardship and management is discussed and in Sec. 9 we present the education and outreach capabilities presented. In Sec. 10 we answer specific questions raised in the solicitation. In Sec. 11 we describe the management of the S-2 proposal and in Sec 12 we summarize our conclusions emphasizing advantages of Homestake.

## **2. Summary of Information on Homestake**

**2.1 Current status of Homestake:** Homestake, a vast former gold-mining facility was owned and operated by the Homestake Mining Company. for most of its 125-year history. The mine played a seminal role in the birth of neutrino astronomy and astrophysics. In 1965 the world's first solar neutrino detector was installed at the 4850 (feet deep) level. In recognition of this achievement, Raymond Davis was awarded the National Medal of Science in 2001 and shared the Nobel Prize in 2002. The underground space potentially available at Homestake encompasses more than 32 cubic kilometers of rock mass. Information on this site has been extensively documented. The radon background is known to be  $\sim 1\text{-}5$  pCi/liter. A cross section of the mine is located at the supporting website as is other information on the mine. There are  $\sim 60$  existing levels spanning the rock mass from the surface to 8000 feet below ground. Approximately 600 km of drifts are spaced at roughly 150-ft intervals connected by many ramps. The water is currently at the 6700 level. The site includes  $\sim 500$  acres of surface area with numerous buildings that can be used as offices, meeting rooms, warehouses or laboratories. Mining operations ended in 2001 and the mine was closed and capped in 2003 by the owners, Barrick Gold Corp. of Canada (Barrick). When the facility closed all surface access ports to the underground structures were sealed and the airflow restricted. Although this action preserved some of the infrastructure by reducing corrosion, it also had the negative impact of halting the removal of accumulating water in the facility. Our plans for intercepting and removing the water are discussed in Sec. 4. In May 2003 an NSF Siting report selected Homestake as the best site for DUSEL, stating: "The panel concludes that Homestake is by far the most favorable site for a DUSEL. Existing access to depth and mining experience that clearly demonstrates feasibility of excavating large caverns at relatively low cost in addition to existing infrastructure made the Homestake Mine an obvious choice. Access via 500 km (300 miles) and more of tunnels at Homestake was especially

favorable to geo-science and engineering studies.” The issues surrounding the accumulation of water in the mine and their affects on the infrastructure and science capabilities are addressed in this proposal.

**2.2 Availability of Homestake:** The plan to convert Homestake into DUSEL was further facilitated on January 12, 2004 when Barrick and the State of South Dakota signed an “Agreement in Principle” wherein Barrick agreed to donate the former Homestake mine to the State for use as Deep Underground Science and Engineering Laboratory. In order to fulfill the requirements of this agreement, the 2004 South Dakota Legislature passed a series of five bills. One bill created the South Dakota Science and Technology Authority (SDSTA) to oversee the conversion of the former mine and to manage this facility for the State. The legislation also provided SDSTA with bonding authority. The remaining bills satisfied other requirements contained in the Agreement in Principle, including appropriations of \$10M for an indemnity fund and other funds for liability insurance and the costs of closure. SDSTA is in possession of these funds (approximately \$14.3M) and they are currently available to facilitate the transfer of the former mine to the SDSTA. In addition, the State of South Dakota has \$10M from a federal grant for rehabilitating the shafts, pumping out water and other uses that will help maintain the structural integrity. Thus the SDSTA is empowered to act as landlord, to hold title to the property, and to provide indemnification and a funding mechanism for development of the site with State bonds. Enacting of this legislation documents the extremely strong South Dakota State and local support for DUSEL, including a substantial monetary obligation. The Agreement in Principle is on the supporting website.

In February 2005 the SDSTA confirmed with Barrick (Sec. 5) that the Agreement in Principle provisions also applied to the creation of a laboratory at the 4850 level and the Board of the SDSTA unanimously adopted a resolution directing the completion of a financial plan (hereafter, referred to as the “Implementation Plan”) for the development of a 4850 level laboratory. The schedule for completion of the Implementation Plan is May 15 2005 (see Table 1 and the more detailed discussion in Sec. 4). The Homestake Scientific Collaboration (HSC), the membership included in supplemental information, and the SDSTA agree on an approach (referred to as the “Conversion Plan”) for converting Homestake into a DUSEL and, in the process, enable early access (referred to as “Early Implementation”) to Homestake for science as soon as November 2006 (see Table 1 and more detail in Sec. 5). The SDSTA contracted with a well respected mine engineering company, Dynatec Ltd., to develop a Conversion Plan for dewatering and rehabilitation of the mine. The SDSTA is prepared to begin, as early as October 2005, the rehabilitation of the Homestake mine to preserve the site for the NSF process for the creation of a deep laboratory. The NSF milestones and SDSTA’s actions are presented in Table 1 and in Sec. 4 and 5.

**2.3 Distinctive characteristics:** Homestake has the attributes needed to support decades of scientific and engineering research across a wide range of depths. The geology in Homestake is well known and characterized. The existing shafts and drifts provide the potential for expedient access to the full underground facility - from the surface to 8000 feet below ground - with modest capital investment (see costs and schedules in Conversion Plan on the website. The drift and ramp systems are well suited to many earth science applications. The rock characteristics indicate large stable cavities can be created at great depths. The large number of existing rooms and other underground spaces can rapidly host scientific efforts at all levels. Our goal is to make as much of the facility available as is needed for the science program developed in the Solicitation-1 Report. The shielding and environmental needs for specific experiments will vary and can be accommodated, but careful attention will also be needed for the common themes of a laboratory: 1) convenient, dedicated access (including well developed regional infrastructure such as roads, railways, and airports), 2) effective program and facilities management sensitive to the needs of a worldwide community 3) technical support and infrastructure, 4) appropriate laboratory size and longevity, 5) a variety of depths and lateral expanse, 6) the ability to accommodate the evolution of the scientific program as new experiments are developed and deployed, 7) an integrated safety program involving the operations staff, site development personnel, visitors, scientific and outreach staff, 8) a diverse outreach and education program integrated into the laboratory and 9) a hospitable, intellectually stimulating environment at the site. Homestake can satisfy all of these common themes.

**2.4 Geological characterization:** An important aspect of the excellent relationship between Barrick, SDSTA, and the scientific community is our access to the Homestake drill-core repository. In this

“library”, there are ~215 km of cores drilled during mining operations. These present both scientific opportunities for study of the rock mass, and provide an essential input in developing new cavity workspace underground. They will be used to prepare preliminary lab designs with substantially reduced risk. This core library provides information of the rock qualities and geological features at proposed locations in Homestake. The library has already contributed to several design studies of large cavities, a complex of deep laboratories for smaller scale experiments, and geophysics/earth science investigations.

**2.5 Safety, environmental issues, accessibility and plan for a laboratory:** During the planning for mine closure in 2003, the underground and surface facilities were inspected by the South Dakota Department of Environment and Natural Resources (DENR), the state’s environmental protection authority. DENR documented the environmental clean up status and the conformance of the mine closure to the closure plan. To proceed, several challenges must be faced: The most important is water accumulation since pumping stopped. The water must be pumped out and the underground access reestablished. Barrick continues to share operational, maintenance, inspection and detailed geological records with the SDSTA and the HSC. A conceptual plan (the Conversion Plan) to regain access, dewater the facility and provide the necessary infrastructure to ultimately create a national facility at Homestake, contracted for the SDSTA, was produced by Dynatec Corp.; a well respected, experienced mine engineering company. This plan to preserve the site, prepare it for early occupancy of the 4850 level and to insure satisfactory conditions for a long-term future expansion is summarized Sec. 4. It has been examined by the HSC scientists and reviewed favorably by a panel of scientists and independent mining experts, and by Barrick. The Conversion Plan and its review are included at the supporting website.

**2.6 Excavated rock disposal:** The conversion plan has identified a number of locations for disposal of excavated rock for the initial preservation of the facility as well as future expansion. For early development of Homestake, adequate disposal sites exist underground. Plans for further modest development will require additional surface disposal sites. Three sites have been identified within the existing site boundaries. Discussions with DENR concerning the necessary minimal permitting requirements have been initiated. For larger developments, such as very large cavities, encouraging discussions have been held with Barrick about using the “Open Cut” for rock disposal. This site could handle more than 50 years of development.

### **3. Qualifications of the Proponents**

We propose a close collaboration between scientists, the SDSTA, and independent mining and engineering consultants to provide the necessary scientific, underground and project expertise (management and design). The scientific team draws from the HSC to coordinate the activities of the proposal, and anticipates participation from all interested individuals and collaborations. The PIs and senior collaborators of this proposal have vast experience in designing and developing underground experiments in underground sites including the Homestake Mine, Yucca Mt, Soudan, WIPP, Sudbury Neutrino Observatory, Kamioka, and Gran Sasso. The SDSTA will be the conduit to the information about Homestake contained within the state agencies (e.g. DENR), Barrick, and the Conversion Plan developed for the SDSTA by Dynatec. Detailed design and engineering of the site and integration of the provisions for access and infrastructure requirements, will be produced with mine engineering teams from RESPEC of Rapid City, S.D., independent mining consultants with experience at Homestake, and experimental facility design teams. The PIs and senior personnel have a strong history of outreach and education efforts with regional and national connections ideally suited for a program at Homestake.

### **4. The Conversion Plan**

**4.1 Status of water in Homestake:** When the facility closed in 2003 all surface access ports to the underground structures were sealed and the airflow restricted. This reduced deterioration of the shafts and ground support by controlling the airflow, humidity and temperature cycling in the underground, preserving the infrastructure for future use. It had, however, the negative impact of halting the removal of accumulated water in the facility.

Pumping of water, both naturally occurring and from mining-activity, is common in all underground mines and was practiced in Homestake. Homestake’s water flows have been characterized; the estimated

~700 gallons/minute inflow is believed to be composed of 2/3 originating from above 5300 level and the remaining from deeper sources. The water is monitored with sensors stationed every 600 feet in the Ross and #6 shafts. Initial inflow estimates slightly overestimated its rate as the monitor at 6800 feet “tripped” about a month behind predictions. Flooding of the facility raises three main issues.

The first is a loss of mine infrastructure, i.e. conveyances, power, air conduits, and ground support. Corrosion of the ground support in the submerged regions may be not as serious as some had originally thought. The near neutral pH water retards the corrosion of the ground support compared to that seen in mines with strongly acidic water. The water quality at Homestake was documented during the mitigation programs to meet EPA requirements during and after operations at the facility. Aspects of possible deterioration of underground infrastructure in the flooded regions are addressed in the Conversion Plan. The Plan replaces all mechanical, electrical and conveyance infrastructure below the 4850 level.

The second issue is the loss of access to the deep underground locations. At present the water in the facility restricts access below the 5000 level. Access from the surface to the 4850 level will not be impacted until the lower sections of the Ross and Yates shaft conveyances are submerged. The water level will remain below the 4850 level until early 2008 if no action is taken. As discussed in Sec. 5, under the SDSTA early Implementation Plan the water will not reach the 5300 level until 2010 or later and will not rise above this level. The upper infrastructure is thought to be in good working order. The hoists, motor generator sets, and cables have been properly mothballed. The Conversion Plan addresses future needs of access to the deeper levels.

The third issue is that the accumulation of water jeopardizes studies of biology and geo-microbiology. The water flow continues to be inwards as it has been for the life of the mine. The enormous hydrostatic pressure of water in the deep rock prevents water from flowing from the mine into the rock. Studies that require unperturbed conditions must drill out of the cone of disturbance created by the inflows as would have been required even if the pumping had continued unabated. Homestake can host these drilling efforts laterally and vertically from many of levels, and we see small and manageable impact for these studies.

**4.2 Previous examples of mine dewatering:** There are many examples of dewatering to reenter mines at different depths. Flooding can occur either suddenly with catastrophic damages or gradually associated with pumping stoppages. The latter scenario is relevant for the Homestake assessment. The mining industry often abandons mines if ore prices become too low; flooded mines are reopened if prices become high enough to make operations profitable again. We describe some examples to illuminate the mining experience. During the operation from 1875 to 1956 in the Orphan Girl mine (shaft to 3,200 ft, Butte, Montana), periodic flooding/dewatering and shut-down occurred: the 1916 litigation, 1921 suspension, 1925 settlement, 1933 restart, 1934 strike, and 1937-39 electric power shortage. The Superior copper mine (~5,000 ft deep, Superior, Arizona) stopped production in 1983, stopped pumping water and let the mine flood in 1986. After 3 years in 1989, the mine was reopened by de-watering over 1500 ft of water and produced copper till 1997. There are currently ongoing negotiations to reopen the same mine and remove the acid water from the current level of ~2,000 ft to extract additional ores. The Agnico Eagle’s Goldex Mine in Quebec is another recent example of dewatering a major facility to regain underground access at comparable depths. For deep mines the task of dewatering is not trivial, however there is considerable experience in the mining industry. West Driefontein 6 shaft in South Africa, after the 1967 flood, was put back into operation and used recently for geo-microbiological coring and sampling, but Evander 6 shaft restoration in the same region was abandoned because it was too costly.

**4.3 Main goals of the Conversion Plan:** One can view Homestake as a two-level facility, the upper levels from surface to 4850 being served by one set of utilities and conveyances and those from 4850 to 8000 by a second set. Currently the facility airflow is sealed. The conveyances have been chaired at the top of the shafts. The water inflow rate and the time scale defined by the NSF’s DUSEL process require some action to be taken soon to preserve the facility – taking no action would result in a more serious loss of infrastructure and ultimately higher costs for converting Homestake to an operating DUSEL.

Actions in the Conversion Plan will halt the advance of the water in the facility at deep levels and preserve the site for the NSF process. The infrastructure in the upper levels will be maintained and in

some cases upgraded. The #6 winze will be converted to permit its operation above submerged levels and to install the necessary equipment to halt the flooding and to begin the steps of restoring the lower levels. The details of the project are in the SDSTA's "Conversion Plan" at the supporting website.

**4.4 The steps in the Conversion Plan:** The process of regaining access to the facility to preserve the site will be performed in a series of steps, each of which is common in the mining industry. The first steps involve inspecting the Ross and Yates shafts for access to the 4850 level and restoring the conveyances. These two shafts will provide redundant access. The restoration will require careful shaft inspections and appropriate maintenance. Logs of the Homestake operations and inspections before its closure describe the condition of the shafts and the estimates of the maintenance required in the shafts. The mine ventilation will be modified for scientific occupancy, limiting airflow only to the regions required for the science program. The ventilation through the drifts will be controlled by installing new control doors on each level consisting of shotcrete bulkheads with man-doors. The surface ventilation system and airflow would be reestablished to permit access to the 4850 and upper levels. Some work is anticipated to clear the air paths and to reestablish mine air exhaust with the Oro Hondo shaft. Pumps and piping will be inspected and replaced as necessary to restart the removal of water from the upper section of the mine. In decommissioning the mine, Barrick left any components that might be needed for the laboratory development, including spare hardware for the shafts, pumps, power distribution transformers, and piping. With the completion of this work, the mine could be opened to project and scientific personnel. Safety is the foremost consideration in this plan. The scientific users would continue this focus on safety and environmental awareness within the culture of safety established in the Conversion Plan.

At the end of the first steps, about two-thirds of the water inflow will be collected and ejected above the 5300 level, significantly retarding the accumulation in the lower levels. From DENR and mining records of the water quality and temperature at the upper levels, we believe only minimal water treatment will be necessary. Permits to deal with this "upper" water have been applied for.

After dealing with the water above 5300 the lower levels will be addressed with the temporary conversion of the #6 winze to winch operation and restoring the ramp system from the 4850 level. A series of portable pumping stations would be lowered into the #6 winze and a floating barge used to maintain the lowest pump on the retreating water surface. Pump capacity will be matched to ensure the water is removed at a rate commensurate with the DUSEL timeline. The ramp system to the water level will likely require maintenance. As the water level retreats additional sections of the ramp will be inspected and rehabilitated. The lower level water will likely require cooling and removal or dilution of dissolved solids. Mining records indicate essentially no metal contamination anticipated.

**4.5 Cost and Schedule for the conversion plan:** On December 3-5, 2004 a committee composed of scientists and engineers met with Dynatec and the SDSTA Executive Director to review the costs and assumptions of the Dynatec plan. The total capital cost of the Conversion Plan as reviewed was less than \$50M, and the annual operating expenses were also reviewed and are dependent on usage. The review document is on the supporting website.

## **5. The Plan for Early Implementation**

**5.1 Strategy for early implementation:** Although the Dynatec plan, summarized in Sec. 4, investigated the effort and cost for conversion of the entire Homestake mine, there is now design work being done on an early underground laboratory implementation utilizing the 4850 level. The main goal of this planning is to reduce the capital and operating costs so that the laboratory can be made available soon.

As discussed in Sec. 4.5 the costs and assumptions of the Dynatec plan were reviewed by independent mining and construction experts. The report of this committee, recommending that the SDSTA proceed with the 4850 level laboratory implementation, was accepted by the SDSTA Board on February 1, 2005. The SDSTA Board asked its Executive Director to develop a detailed early Implementation Plan for the establishment and operation of the 4850 level laboratory to be considered at its May 16, 2005 meeting. On February 16, 2005, Barrick, in a letter to SDSTA, stated that a properly funded and permitted 4850 level laboratory was within the definition of underground laboratory as specified in the Agreement in Principle previously executed on January 12, 2004 (The 2/16/05 letter is available on the website).

**5.2 Scope of early implementation:** The 4850 laboratory will provide a unique underground laboratory. It will be the deepest laboratory in the United States and the second deepest laboratory in the world. It will provide a very large space on the 4850 level for new experimental chambers and provide a cubic kilometer volume for exploration by geoscientists. From direct rock strength measurements using the Homestake core repository, it has been established that chambers with spans of 50 meters can be readily and safely constructed at this level.

The main axis of the 4850 laboratory will be the 2900 ft long, 13 ft by 15 ft cross section drift that connects the Ross and Yates shafts, the two main surface to underground access shafts. At the Yates end of this tunnel is the 2000 m<sup>3</sup> chamber that housed the chlorine solar neutrino detector. There are 30 levels between the surface and the 4850 level, providing a 3-dimensional matrix for geophysical investigation. Exploratory downward and sideward drilling into virgin rock for biological and geophysical investigations can be carried out at a number of sites at the 4850 level without disturbing any of the other experiments. Rock excavation and cavity construction, necessary for the complete Conversion Plan for DUSEL, will not disturb existing experiments on the 4850 level or expose them to rock dust.

**5.3 Schedule and management for early implementation:** The remaining steps in the transfer process are: (1) the SDSTA, the State of South Dakota and Barrick accept the Implementation Plan, which is anticipated to occur by June 15, 2005, (2) funds for the work involved in obtaining safe access to the 4850 level, (est. \$15M) from the State of South Dakota and/or other sources available to the State, will be secured by July 15, 2005, and (3) transfer of title to the laboratory site from Barrick to SDSTA will be completed by October 1, 2005. (See Table 1).

In anticipation of the above sequence of events, on **February 25, 2005**, the SDSTA formally requested a water discharge permit from the DENR. The issuance of such a permit can require up to six months and should be issued by August 25, 2005. Of the 700 gallons per minute water that presently seeps into the mine, 480 gpm comes from sources above the 5300 level. As part of the 4850 level Implementation Plan, there will be a provision to pump all water entering the mine above the 5300 level. Most of this water is direct inflow of surface water and it is anticipated that it can be pumped back to the surface and discharged with little or no additional treatment. Reducing the inflow by over two-thirds will keep the water level below the 5300 level until at least 2010 and possibly longer. The pumps installed at the 5300 level will insure that water will not rise above this level. Any water below the 5300 level can rapidly be removed in the construction of the 8000 foot deep DUSEL. The plan indicated the full conversion could be accomplished in ~ 18 months.

In the summer of 2005, the SDSTA will begin solicitation of bids to carry out the work necessary to establish the 4850 laboratory. This work will begin on **October 1, 2005** and be completed by **May 1, 2006**. The work plan consists of establishing safety procedures, inspection and any necessary repairs of both the Yates and Ross elevator shafts and any required maintenance and improvements, the establishment of a new ventilation system, inspection of the 4850 level drifts, sealing of any drifts at shallower levels that are not needed for the geosciences or geomicrobiology research effort, and the pumping of water that is flowing into the mine from above the 5300 level.

About **June 15, 2005**, Letters of Interest (LOI) will be solicited from the science and engineering communities for experimental use of the 4850 laboratory beginning experiment installation in the spring of 2006. The SDSTA and the HSC will consult with the NSF about establishing laboratory management and procedures for consideration of these proposed experiments. Some experiments will be able to utilize the large rooms that currently exist on the 4850 level. Other experiments may require the excavation of special chambers, which will be estimated separately. The SDSTA will provide engineering assistance for the planned experiments and will review each experiment for safety prior to installation.

**5.4 Cost for early implementation:** It is anticipated that the total capital cost for the 4850 lab is approximately \$15M and the annual base operating cost of the infrastructure will be approximately \$2M for the first 5 years. Additional requirements by various experimental groups may increase this number. Funds for the work involved in obtaining this early safe access from the State of South Dakota and/or other sources available to the State, will be secured by July 15, 2005.

## **6. The Plan to Develop an Initial Suite of Experiments**

Discussions within the HSC indicate that a substantial scientific program could be undertaken at the 4850-ft depth. The preserved site with its huge section of underground drifts and stopes for immediate uses will be available to the earth science community. At the 4850 level there are a large number of rooms and spaces that could be rapidly converted to laboratory use. As indicated in Sec. 5, additional experimental spaces can be made at modest cost off of the 2900 ft drift between Yates and Ross shafts. Being a dedicated facility, it would be without interferences and uncertainties encountered in facilities sharing infrastructure with active mining operations. The early access would empower earth sciences with their first long-term dedicated site and one with a large underground footprint. Particle and nuclear physics could begin with time-critical prototyping and R&D in a deep facility superior to those currently existing or likely to exist in the coming ~5 years.

### **6.1 Strategy for early experiments:**

**Physics:** We first list common characteristics of physics experiments for which immediate early access into Homestake would be important for advancing the science goals of DUSEL. 1) Experiments that are ready for installation within the next year or two, some of which are presently negotiating with other sites for space. 2) Underground experiments presently operating at shallower depths and that would benefit from a greater reduction in cosmic ray background and thus greater depth for their further development. 3) Less advanced experiments needing underground space to test and evaluate prototypes or to develop new detectors and technologies. This includes shared infrastructure such as ultra-low background counting and screening facilities. 4) Some of the other experiments now only on the drawing boards may need to store construction materials in a reduced cosmic ray environment.

Some experiments may find the cosmic ray flux at the 4850 level low enough for their needs in the immediate future. Based on the presentations at the various recent underground science workshops, we anticipate receiving LOI's from and perhaps initiating experiments in neutrinoless double beta decay, dark matter, and solar neutrinos. It is possible to begin R&D and construction for a large, ~100 kiloton neutrino and proton decay detector. The 4850 level can readily accommodate this entire group of experiments. For experiments that ultimately require the much lower cosmic ray flux characteristic of the deeper locations in Homestake, initial operation at the 4850 level will permit testing, staging, detailed background study and allow rapid and efficient transfer to the lower level laboratory at a later time.

**Earth Sciences and Engineering:** SDSTA's plan to reoccupy and convert the facility down to the 4850 level as early as 2006 permits shallow through deep geoscience experiments as soon as construction occurs subject to safety constraints. Geoscience experiments that can be initiated in concert with this rehabilitation of the laboratory after safe access to drifts has been established include: 1) investigations of water flow path delineation in heterogeneous geologic settings, 2) determination of rock movement that occurs as part of the normal deformation of the underground facilities without additional mining, and 3) characterization (e.g., biological, chemical, and isotopic signatures) of seepage from various locations.

Many attractions of Homestake were cited in the findings of the 2003 EarthLab report to NSF. Extensive mining provides access to large volumes of rock, and large blocks of virtually pristine rock are readily accessible for experiments requiring these conditions. The ground water flow and recharge deserves further studies to better characterize flow in other crystalline terrains. Metamorphosed clastic, carbonate units, iron formation, and mafic volcanics (2 billion year old) with lesser amounts of more recent intrusive rocks (~50 million year old) dominate the Homestake geology. These rocks provide a diverse and varied environment for geologic investigations. Studies might involve variations in stress, fracturing and other geomechanical properties. These geomechanical insights can be integrated with investigations of low and high temperature large-scale fluid-rock interactions to better understand this gold deposit. Establishing the geotechnical behavior of the Homestake rock types, including the Yates metavolcanic unit, will allow design and excavation of experimental chambers with long-term stability.

Some early characterization activities such as fracture mapping, stress measurements, and ground-water chemistry will likely be expanded as access to various locations within the facility is established. Other investigations such as those looking at thermal-mechanical-hydrologic coupling would expand in scope

(i.e. from less than 1 m<sup>3</sup> to 100 m<sup>3</sup>) as larger blocks of rock become available. The experience gained from developing the early stages of these experiments would be invaluable for a potential deeper stage, which would extend the laboratory down to 8000-ft.

**Geobiology:** 1) Recent advances in genomics, proteomics, metabolomics, microarrays, and complex data processing make it possible to examine adaptation and evolutionary shifts occurring in a mere century. Homestake represents a unique opportunity to demonstrate short time-scale evolution in a dramatically altered environment while validating developing genomics tools. The subsurface underwent dramatic changes over the past century from a lower redox, low permeability, long term isolated subsurface to an aerated, cavernous, fractured environment with high volumes of air, water, hydrocarbon, excavation and fill materials, and animate movements complemented by biofilms on exposed rock faces. It is hypothesized that in addition to selection, colonization and niche occupation by surface and subsurface flora and fauna there has likely been significant adaptation and evolution. Genomic profiling and advanced microarrays technologies will enable identification of slight evolutionary alterations in genes and functions while proteomic and metabolomic based efforts will identify adaptations and or evolutionary changes in proteins and organismal functions. 2) Homestake offers unique opportunities to examine human impacts in what is arguably the largest hole in the Earth in the western hemisphere. Human impacts include a wide array of activities resulting from mine operations including mammal rearing, petroleum hydrocarbon usage, immense water recirculation and cooling infrastructure, altered subsurface temperatures, air flow and oxygen inputs more than a mile deep and even the provision of a century plus lighting in a previously dry and dark isolated fractured rock. Immediate scientific opportunities exist in areas at the 4850 level and shallower where human impacts have been the longest and include animal rearing zones, miles of backfilling, air and water handling systems, and the impacts of tunneling. 3) Advances in bioprospecting could commence immediately upon mine availability. Direct environmental screening for DNA, RNA and novel proteins as well as microbial enrichments from rocks waters and biofilms will be investigated. Processes of interest will include energy coupling, bioremediation, production of secondary metabolites and antibiotics, thermophilic and extremophilic capabilities, and or accomplishment of novel processing or otherwise interesting natural products of biotechnical significance. 4) An early start could be made on coupled biogeochemical processing, biomineralization, and microbial metabolism of century-old prokaryotic and eucaryotic subsurface biofilms. Sampling of bacteria by drilling into virgin rock from accessible drifts would also serve as a prelude to the major geomicrobiological research anticipated during the DUSEL stage of the laboratory.

**6.2 Mechanism for establishing the early scientific program:** To establish the early 4850-level science program, we envision an iterative process driven by a series of topical workshops, a call for Letters of Interest (LOI) and the establishment of an Interim Program Advisory Committee.

The approximate schedule for the operation of the facility and a number of prominent milestones are presented in Table 1. The scientific program will use three steps to gather the information necessary to specify the laboratory requirements and infrastructure. First, the HSC will use NSF S-1 documentation to generally define the site requirements for different classes of experiments. The HSC has already hosted several meetings and workshops to further define these general programmatic needs for the interim period. These two processes have begun to define the needs and timeline for the next ~five years and to address experimental requirements including underground and surface footprints, power, HVAC, cooling, room surface requirements, safety, and environmental requirements. The SDSTA and the HSC have begun to match this information to the existing rooms, drifts, and the existing surface facility. Finally the HSC will accumulate a detailed list of requirements and timelines and work with the SDSTA in requesting Letters of Interest from international scientific collaborations, both during and after a series of seven topical workshops as described below. With these three steps, the initial roadmap for Homestake will make appropriate association of potential experiments with specific rooms and drifts.

To accomplish the final accumulation of requirements and to plan for the underground and surface space assignments, as part of the S-2 process the HSC will host a number of focused workshops on distinct scientific or outreach topics: 1) geo-microbiology, geochemistry 2) geosciences (including

hydrology, economic geology and rock mechanics) 3) education and outreach 4) low background physics: dark matter, solar neutrinos, double beta decay and accelerator-based nuclear astrophysics 5) physics requiring large facilities: long-base-line neutrinos, proton decay and atmospheric neutrinos, and other large users (experiments using shafts and drifts e.g. for microgravity, atmospheric sciences and N-Nbar) 6) coordination of facility needs and design, 7) management. These workshops will advance the concepts developed from the first three sources listed above into a preliminary plan. In addition to the scientists and educators the workshops will involve the underground construction team from SDSTA and their Conversion Plan contractors (Dynatec) and advisors, and HSC engineers and designers. The plans developed from these workshops will be converted into engineering plans with sufficient detail and specifications so that experimental and facility planning can proceed to the detailed engineering stage. Experiments can then prepare proposals and seek sponsorship and the facility plan for scientific occupancy. The Request for Letters of Interest and the planning workshops will be open to U.S. and international participants.

Having established the plans for scientific uses it is important to oversee the scientific program to ensure safe and efficient use. The SDSTA is seeking additional occupants that may include industrial, governmental and additional scientific and outreach uses. The interim scientific management will need to ensure that all activities can make optimum and coordinated use of the campus. The HSC and SDSTA have begun discussions on scientific oversight. As part of the S-2 process these arrangements will be researched (including examples from Canada, Japan, and Europe) and finalized. See section 8.

## **7. The 30 year Capability Beyond the Initial Experiments**

**7.1 Long term expansion at Homestake:** The SDSTA has addressed most of the obstacles for the future development of Homestake by initiating the actions necessary to preserve Homestake, obtaining title, providing indemnification, and initiating rehabilitation and water removal. Two issues for the long-term future are: 1) Large scale rock disposal, and 2) Water removal from the lower levels.

Existing rock disposal sites have been identified above and below ground. Permitting of most of these sites will not be required or can be obtained easily as they are within the site boundaries. The deep laboratory will require the identification of additional disposal sites for excavated rock for larger excavations. Discussions between SDSTA and Barrick have been initiated about using the “open cut” to dispose of large quantities of rock. This use will require the approval of DENR, but initial discussions have not identified any showstoppers.

The environmental issues associated with dewatering of the facility benefit from a century of pumping water from the mine and the South Dakota DENR experience with Homestake. The Conversion Plan concentrates initially on the removal of the water from the upper levels. The upper level water is expected to be mostly surface water, and SDSTA and the DENR are discussing disposing of this water into traditional waterways. We anticipate that permitting can be readily obtained following the initial sampling. Water from the lower levels of Homestake will require further sampling to finalize the permitting and design of treatment facilities. It is anticipated that the water quality of the lower water will require substantially less treatment than was necessary when the mine was in full production.

**7.2 Long term planning for Homestake:** In the S-2 process we intend to prepare a long-term road map for the science program at Homestake. Having established a scientific roadmap with these series of workshops we will work with the SDSTA and develop the detailed plans for the deep laboratory spaces, the large cavities, the deep facilities for geo and bio-sciences.

The four important issues for the long term are 1) identification or development of new rooms, drifts, and ramps at the deepest levels, 2) development of large caverns with 30-50 year life-spans, 3) infrastructure for accessing the interesting geological features (e.g. the very deep) for geosciences and biology, 4) long term development and construction in the site without disturbance to the on-going science program.

The scientific roadmaps for the long-term laboratory will be prepared in an analogous fashion to the intermediate facility – through a series of workshops and meetings. The input from the workshops will be coupled to a second round of planning sessions involving engineers and designers familiar with underground construction and with scientific experiments.

Expanding the laboratory, while maintaining the existing scientific program, will require careful planning to keep interferences to a minimum. Recent experiences in Sudbury have demonstrated that large and very sensitive experiments can successfully operate while excavations and construction take place within 100 m. The existing rock-hoisting capacity, sized for a working mine, can easily accommodate construction of facilities for science. Homestake has two separate conveyances to the surface from the 4850 level that will separate access for scientific and personnel from rock transport and mining functions. Transportation of rock from the deeper levels to the surface will be skipped to the 5000 level by the #6 Winze and then to the surface by use of the Ross hoist thereby bypassing the 4850 level.

**7.3 Neutrinoless double beta decay, dark matter, and solar neutrino detection:** Clearly, the scope of these experiments in the future will be considerably larger, and will require advances in experimental techniques, larger collaborations and additional funding. The common characteristics of these experiments are modest size, instrumented with highly sensitive equipment that need a well-controlled environment and in some cases clean facilities.

The APS Neutrino Matrix report provides the strategy for addressing double beta decay physics in three ranges of increasing sensitivity, related to known neutrino-mass scales of neutrino oscillations. The initial program at Homestake in the previous section can address the first step: 100-500 milli-eV range also called the quasi-degenerate region. The 20-50 meV range arises from the atmospheric neutrino oscillation results. Observation of neutrinoless double beta decay at this mass scale would imply the inverted neutrino mass hierarchy or the normal-hierarchy mass spectrum very near the quasi-degenerate region. To study the 20-50 meV mass range will require experiments of  $\sim 1$  t mass, preferably with independent techniques. The 2-5 meV range arises from the solar neutrino oscillation results and will very likely lead to the neutrinoless double beta decay, provided neutrinos are Majorana particles. To reach this goal will require 100 t of the decaying isotope, and no current technique provides such a leap in sensitivity. Homestake can, nevertheless, accommodate all three stages of this experimental program over the 30-year period.

The importance and strategies for dark matter detection are summarized in several reports including the “The Physics of the Universe”. One of the key strategies is to look for relic Dark Matter particles passing through highly specialized detectors designed to detect the extremely weak signal of a rare Dark Matter interaction with a massive nucleus, coupled with strong suppression of background signals that could overwhelm this signal. This requires placing detectors deep underground to shield from cosmic rays. For example, the Cryogenic Dark Matter Search (CDMS) and its follow-on, CDMS-II, aim to measure the Dark Matter particles through collisions in the crystals of silicon and germanium with highly sensitive electronics. Other technologies, such as cryogenic Xe, are being developed. The long term goal is to obtain a total mass of  $\sim 1$ -10 t. Detectors of this size can certainly be accommodated at Homestake, however, careful attention will be required to the safety issues regarding the cryogenic fluids at any site.

For solar neutrinos, the future interest lies in the information about the Sun contained in the solar neutrino spectrum. Neutrinos are the only particle to tell us details about the inner workings of the Sun. Although the predictions of the Standard Solar Model have been confirmed, we have not yet examined in detail more than 99% of the solar neutrino flux. The discovery and understanding of neutrino flavor transformation allows us to return to the original solar neutrino project—using neutrinos to understand the Sun. This could form the basis of a 30-year program to monitor the solar neutrino flux and the spectrum. Detectors required are  $\sim <1$  kt depending on sensitivity and technology.

**7.4 Large detector cavities and long baseline neutrinos:** Several prominent reports (e.g. The APS neutrino matrix report) indicate the need for a very large multipurpose detector coupled to an accelerator based intense neutrino beams. Massive detectors have been key to the recent revolution in neutrino physics. Their significant cost is appropriately justified by the diverse physics program made possible by a multipurpose detector. Such a detector should be capable of addressing observations of nucleon decay, solar neutrinos, supernova neutrinos, and atmospheric neutrinos in addition to long-baseline neutrino physics. The broad range of capabilities, however, can only be realized if it is built deep enough underground. It also is clear that very large-scale, long-baseline experiments will provide the best

sensitivity to all the oscillation parameters as well as to possible unanticipated new physics. They also provide the only possibility for quantitatively exploring CP-invariance violation in the neutrino sector. A proton driver in the megawatt class or above used to produce a neutrino superbeam, together with a detector mass of more than 100 kt, should probe all aspects of three-generation neutrino mixing, unambiguously determine the mass hierarchy, and provide definitive information on the amount of CP-invariance violation, as long as the 1-3 mixing angle is sufficiently large. Planning for a suitable accelerator facility to provide such a beam is underway at both Brookhaven National and Fermi National Accelerator Laboratories. The program using large detectors and intense neutrino beams is expected to evolve over at least 2 decades. Homestake can accommodate such a program and this will be an important subject of S-2 planning workshops.

**7.5 Long term projects in geosciences:** Over the next century and beyond, earth scientists and engineers will be confronted with many critical challenges requiring significant advances in our understanding of the underground environment. To make meaningful progress towards understanding the science and engineering issues necessary for addressing topics such as energy resources, water resources, and mineral resources as well as hazardous waste disposal and carbon sequestration will require broad, multi-disciplinary research projects that are ideally suited for an underground research laboratory. We anticipate that the major areas of thrust in geosciences at Homestake will address: 1) What is the impact of surface and near-surface processes on the underground environment? 2) How do increasing depth and temperature affect rock properties and the stability of deep, engineered volumes? 3) Can terrestrial climate records be extracted from subsurface mineral deposits? 4) How do hydrothermal fluids and magmas move through the crust? Homestake is ideal for these and other studies because of the great vertical and lateral extent of available access, the variety of different rock types, and the diverse surface features that are present above the mine (e.g., undisturbed soils, the Pre-Cambrian/Paleozoic unconformity, the open cut). There are also special circumstances at Homestake such as the small tertiary intrusive bodies exposed in the lower sections of the mine that created a large geothermal system and the understanding of crustal processes responsible for the genesis of the Homestake gold deposit.

Long-term experiments (10 to 50 years duration) include large, manipulated test blocks with thermal, chemical, hydrological, mechanical, biological processes, coupled with each other, driving the gradients and altering rock permeability. The present infrastructure at Homestake renders these types of experiments feasible -- much of the excavation and development work is already accomplished. DUSEL will offer a unique opportunity for development and testing of geophysical methods for remotely characterizing the subsurface.

**7.6 Long term projects in biological sciences:** Four thrust areas have been identified where major scientific advances in geo-bioscience at the Homestake DUSEL can be made with a modest investment. The four thrusts include: 1) Examination of ecogenomics in a rapidly perturbed isolated subsurface environment which capitalizes upon the history of interaction between human activity and the microbiology ecosystem at Homestake, 2) Bioprospecting for novel genes, traits in deep isolated subsurface environments, 3) Understanding of coupled biogeochemical process in deep isolated subsurface environments, and 4) Investigation of the limits of life on Earth by drilling deeper from the bottom portions of this 2.4 km deep facility. As explained in the previous section much of this work can start immediately after the Conversion Plan begins. For the longer term we will expand on the vertical access already available in the mine with a series of deep boreholes collared in the lower levels of the mine in order to reach higher temperature and pressure regimes. The main purpose of these boreholes will be to search for the limits of life in the subsurface.

## **8. The Plan for Management of Operations, Safety, and Scientific Program**

The Agreement in Principle defines transfer of property title to the SDSTA. The State of South Dakota has provided the necessary indemnification and liability insurance and created the SDSTA to enable the transfer. In the early Implementation Plan and subsequently, the SDSTA will operate and maintain the basic underground and surface facilities and services. These include 1) safe underground access, 2) the environmental, health and safety program including life-safety and mine training, and 3) the basic

infrastructure for the underground and surface facilities (power, HVAC, industrial water, etc.). The safe and efficient use of the facility requires that the scientific programs and other users of the facility be carefully managed and coordinated with the maintenance and operations (M&O) functions.

The HSC and SDSTA have begun discussions on scientific management, coordination, and M&O for the early Implementation Plan. One model is for the HSC's Executive Committee, augmented with appropriate management and underground engineering experts, to provide this management. As part of the S-2 workshops these arrangements will be researched, input sought from funding agencies, and an interim scientific management entity established. Establishment of DUSEL at the end of the NSF process will require additional consultation with funding agencies and scientific management entities. This process will be initiated with the S-2 workshops, and continued in the S-3 solicitation.

## **9. Education and outreach**

Homestake provides a unique opportunity for education and outreach. Education and outreach is one of the top priorities of the SDSTA. The existing Homestake surface facility, its historic nature, and the existence of strong outreach efforts in South Dakota and neighboring states will enable a strong and early implementation of programs centered at Homestake. The surface footprint directly above the laboratory includes over 500 acres with numerous existing buildings and associated infrastructure. Education and visitor facilities can be readily converted from these buildings in a cost effective manner. Homestake is located in the beautiful Black Hills, a destination for over 2 million tourists per year. A visitor center would be a positive addition to local attractions such as the Mining Museum and Mount Rushmore.

The two local universities, Black Hills State University and South Dakota School of Mines and Technology, are prepared to collaborate to bring science and education programs into the center. The two area Native American colleges, The Ogalala Lakota College and Sinte Gleska University, will also collaborate. Involvement will also be obtained from the neighboring EPSCoR States and the K-12 Board of Education. Contacts have also been made with notable national outreach efforts including QuarkNet and NASA. Montana Tech is willing to contribute expertise in rock mechanics, its record of involvement of a gender-diverse population in applied research, and ties to the NIOSH Spokane Research Laboratory, and Dakota State University its computer and information systems technology. A workshop was held on education and outreach in the fall of 2001 and a white paper was produced on January 17, 2002. This detailed white paper is on the supporting website. It emphasizes programs for students such as summer camps, research internships, creation of research libraries, and computer networking for distant learning. Another aspect is the teaching of teachers. A collaboration between HSC and The Center for the Advancement of Mathematics & Science Education at Black Hills State University, which has already received \$5M in NSF funding for science teacher education, will help in this national priority.

A workshop on education and outreach was held by the HSC in November 2004. The proposed workshop on education and outreach will update the white paper of 2002, incorporate the work done at the November 2004 workshop and further define the possibilities for education and outreach.

## **10. Answers to Specific Questions in the Solicitation**

***Geological characterization of the site:*** The Homestake site is extensively characterized by over a century of mining operations. The existing information that spans the entire facility is available to the collaboration by way of the Homestake core repository and mining and geological records from the Homestake Mining Company. The drill core repository is discussed in **Sec. 2.4**.

***Environmental assessment of the site:*** The environmental status of the site is addressed in the closure plan submitted by Barrick and inspected by the South Dakota DENR. The only additional assessments required for the early implementation are the water discharge and rock disposal permits discussed below.

***Health and Safety:*** The Homestake Mine had a strong safety record. The Conversion Plan will continue this record of awareness to health and safety. The Conversion Plan will develop a culture of safety integrating operations, experiments and visitors. A discussion of the environmental, health and safety plans for the Conversion Plan are contained in the review of the Conversion Plan at the website.

***Permitting:*** The necessary water discharge permits for dealing with water pumped above the 5300 level have been applied from the DENR. Adequate rock disposal sites for the early Implementation Plan within

the mine and within the boundaries of the surface facility have been identified by the SDSTA. No additional permitting is needed for these locations. SDSTA has initiated discussions for the use of the “Open Cut” for larger scale rock disposal.

**Local support:** The State of South Dakota is committed to establishing a deep underground lab at Homestake. Actions taken by the state legislature to enable the transfer of the site are summarized in **Sec. 2** and at the supporting website. Additional letters of support from the state, from local officials, education and community groups are included in this proposal.

**Sharing infrastructure:** Homestake will be a dedicated facility and will not share infrastructure with mining or transportation functions. Additional uses, other than science experiments, of the facility are anticipated, including space for other government entities, industry, education and outreach. Coordination of these will be through the scientific management of the laboratory, presented in **Sec. 8**.

**Managing uncertainty in developing Homestake:** Reuse of an existing well-characterized facility greatly reduces major sources of uncertainty and risk. Reopening the facility with SDSTA’s Conversion Plan and the early implementation of the plan further reduces risk and uncertainty in development of the site. Additional drill coring will be performed prior to new underground development.

**Timeliness and costs:** The Conversion Plan was reviewed at ~ \$50M and with a schedule of ~18 months to obtain access to the 8000 level, and fully dewater the facility. The schedule depends on the level of water in the facility. The early Implementation Plan, obtaining access to the 4850 level, the cost of which is estimated by the SDSTA to require ~\$15M capital and 7 months with annual operating costs of ~\$2M per year. The majority of the costs and time for the early Implementation Plan would be deducted from those listed for the full Conversion Plan. The early Implementation Plan would be financed from funds secured by the State of South Dakota. See sections 4, 5 and the supporting website.

**Developing, operating and maintaining the infrastructure:** These issues are presented in the Conversion and Early Implementation Plans, presented in **Sec. 4 and 5** and at the supporting website. The initial development, operations, and maintenance of the facility would be undertaken by the SDSTA.

## **11. Management of the S-2 Solicitation and Timelines**

The HSC Response will be sponsored from and managed through the University of California, Berkeley Physics Department. Dr. Kevin T. Lesko will be the PI on the Grant. Dr. Lesko is a senior physicist at Lawrence Berkeley Laboratory and a Research Physicist in the Physics Department. Bill Roggenthen, Dean, College of Earth Sciences, South Dakota School of Mines and Tech. will be co-PI. Subawards and contracts will be established with the other participating institutions, including the mining engineering consultants and the SDSTA, as required. The award will be used to host the workshops, provide travel support for the workshops, support the engineering and design work through contracts with underground construction consultants (RESPEC Consulting and Services, and several independent mining contractors) and engineering and design personnel within the collaboration. An administrative assistant will provide part-time support to coordinate the workshops and the reports from the workshops. Salary support for the PI will be included for the duration of the award as well as several senior personnel. The co-PI and senior personnel will organize and lead the workshops to ensure appropriate focus and leadership of the specific fields and topics. The workshops will be conducted in two steps, summarized in Table 1, the first step will be to gather the information from Letters of Interest for experiments in the early Implementation Plan and the second step will be to review this information, in consultation with engineering and design consultants and prepare a detailed engineering plan. The site requirements for experiments and the engineering plan will form the basis of the design report for Homestake.

## **12. Conclusions**

Homestake presents a low risk and extremely competitive site for the development of a dedicated DUSEL. Homestake can host a comprehensive suite of experiments in all major fields of science. It is expandable over 30 years to accommodate an evolving scientific and outreach mission. It has areas of strong rock that can accommodate large detectors as well as areas with diverse geology for geo- and bio-sciences. We have a detailed Conversion Plan with documented cost and schedule. An early implementation of this plan will result in a science facility in advance of the NSF site selection process.

As a product of this grant, we will develop a conceptual design that incorporates the goals and means to a realization of the Conversion Plan and its early implementation. The partnership between the scientific community and the State of South Dakota, as currently expressed by the HSC and the SDSTA, combined with the wealth of information from the former operation of the facility provides us with a promise for a safe, dedicated, well-understood, large and deep site with reasonable cost and schedule.

### **Results from Prior NSF Support**

(M.1) PI W. M. Roggenthen, Award no.: ESI-9819643; Amount \$136,215; 6-1-99 to 5-31-05 Project:

"Black Hills Science Teaching Project (BLAHST)"

BLAHST promotes exemplary K-8 science teaching in 10 Black Hills school districts through the introduction of classroom science materials and targeted professional development. As of the end of 2003 (statistics for last year are still being compiled), BLAHST had provided over 29,600 hours of professional development through an average of 75 days of training per year. We currently serve 430 teachers. We provide on average just over 70 hours of professional development for eligible classroom teachers. Our focus is most on science content and some on pedagogy, leadership, inquiry, and the integration of science with math and language arts. Preliminary results were presented at NeSS.

**TABLE 1**

**Homestake DUSEL Laboratory Development Schedule. Items marked with have been completed**

<b><u>January 12, 2004</u></b>	“Agreement in Principle” between Barrick and SDSTA to transfer mine.
<b><u>February 11 2004</u></b>	Legislature passes necessary enabling and appropriation legislation to effectuate transfer and provisions in the Agreement in Principle.
<b><u>July 2004</u></b>	State funds \$14.3M to enable site transfer and operate SDSTA
<b><u>February 1, 2005</u></b>	SDSTA Board approves development of fiscal and management plan (Implementation Plan) for 4850 level laboratory
<b><u>February 16, 2005</u></b>	Barrick confirms establishment of the 4850 level laboratory satisfies the definition of laboratory in the Agreement in Principle
<b><u>February 25, 2005</u></b>	SDSTA initiates application for a water discharge permits with the South Dakota Department of Environmental and Natural Resources (DENR)
<b><u>February 28, 2005</u></b>	Submission of Homestake S-2 Response to the NSF
<b>May 15, 2005</b>	4850 level Laboratory Implementation Plan submitted to the SDSTA Board
<b>June 15, 2005</b>	Implementation Plan accepted by SDSTA, State of South Dakota and Barrick.
<b>June 15, 2005</b>	Request for Letters of Interest
<b>July 15, 2005</b>	Funds for the 4850 level laboratory access are secured
<b>August 25, 2005</b>	DENR Water discharge permits received by the SDSTA
<b>August 2005</b>	Review of S-2 submission. 1 <sup>st</sup> round of workshops gathering experimental requirements and criteria for the science and education and outreach programs
<b>October 1, 2005</b>	Transfer of the Homestake site from Barrick to SDSTA completed
<b>October 1, 2005</b>	Begin work on site rehabilitation and the 4850 level laboratory access
<b>January 1, 2006</b>	2 <sup>nd</sup> round of workshops defining engineering plan for Scientific Programs, Education and Outreach and Deep Lab Development
<b>May 1, 2006</b>	4850 level ready for construction of new experimental chambers and/or occupancy of existing chambers
<b>November 1 2006</b>	Complete modifications to existing underground 4850 space and begin experiments